Scheduled West Coast Missions

Channel Islands National Marine Sanctuary
The primary objective during the first year of the Sustainable Seas Expeditions will be characterization of benthic habitats and their associated flora and fauna. The DeepWorker will be used to investigate the geology and biology of the sanctuary and describe the relationship between physical features and deep water biological communities. Special attention will be paid to species that may be indicators of ocean health such as white abalone, bocaccio, giant seabass, cowcod and squid. A broad range of sediment types and topography, including faults, folds, terraces, slopes and areas of sediment deposition, also will be targeted. Future long-term monitoring sites will be established so that the health of these deep sea areas can be followed.

Benthic habitats in and around reserves closed to fishing will be areas of focus. In the Santa Barbara area, several nearshore reserves have been established. Experiments are currently being conducted and additional studies are being planned to test the effectiveness of reserves as nurseries that provide spillover of harvestable resources and as refuges for mature fish whose larval production "reseeds" areas outside the reserve. Assessing the effectiveness of these reserves in fisheries restoration requires a detailed habitat characterization to determine if sufficient habitat exists to sustain species of concern. The DeepWorker will be used to explore areas for which sidescan sonar data has been collected. Bottom video will assist in "ground-truthing" where interpretation of the sidescan data is uncertain. Accurate habitat characterization and mapping can provide baseline data essential to managing the resources of the Channel Islands National Marine Sanctuary.

Additional projects planned for this first year include collecting data on spawning habitat of market squid, an important fishery resource in the Santa Barbara area.

Scheduled Dive Projects

- Benthic habitats of the Channel Islands

PI: Guy Cochrane

- Deep water exploration of the Channel Islands
  PIs: Milton Love
- Survey of Market Squid, *Loligo opalescens*, Spawning Habitat
  PI: Edward Cassano

Ancillary Projects

These projects are subordinate to the scheduled dive projects. In many cases, the principal investigators for these projects will not be aboard. Data for ancillary projects will be collected incidentally during the scheduled dives or

as time allows. Ancillary projects may also include nighttime operations that do not involve the use of the DeepWorker.

- Taxonomic atlas of benthic fauna
  PI: Valentich Scott
- Sidescan sonar investigations
  PI: Guy Cochrane
- Plumes and blooms
  PIs: David Siegel, Michael Neumann
- Deep water fish assemblage characterization for the National Marine Sanctuaries
  PI: Laddie Akins
- Survey and inventory of echinoderms
  PI: Gordon Hendler
- Suspension-feeding assemblages on deep shelf and upper bathyal hardgrounds, with an emphasis on Crinoidea (Echinodermata)
  PI: Charles Messing

Cordell Bank National Marine Sanctuary
Investigations in the first year of the Sustainable Seas Expeditions (SSE) will focus on site characterization. The primary objective will be to survey the top of Cordell Bank and assess algae, invertebrate, and fish populations and habitat. A second objective will be to investigate fishing impacts on the Bank.

Site characterization data is fundamental for effective management and protection of sanctuary resources. The spectacular diversity and productivity of the sanctuary are qualities that contributed to its designation. Cordell Bank has been identified as one of the most critical and fragile fisheries habitats in California. It is a major sport and commercial fishing destination with boats targeting rockfish and other species of bottomfish. The Bank's high relief bathymetry, with pinnacles, holes and ridges, provides optimal habitat for juvenile and adult rockfish. Because of its depth, the few scuba expeditions completed in the early 1980s mapped only the tops of the highest pinnacles, and Cordell Bank remains relatively unexplored. Year-one missions will help inventory and characterize sanctuary resources by describing community structure at Cordell Bank and establishing monitoring sites and transects for baseline and long-term studies.

Scheduled Dive Projects

- Baseline resource inventory
  PI: Dan Howard and Natalie Cosentino
- Assessing fishery impacts on critical habitat
  PI: Dan Howard

Ancillary Projects
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- Ecosystem dynamics study
  PI: Dan Howard
- Lingcod tagging project
  PI: Tom Laidig
- Deep water fish assemblage characterization for the National Marine Sanctuaries
  PI: Laddie Akins
- Survey and inventory of echinoderms
  PI: Gordon Hendler
- Suspension-feeding assemblages on deep shelf and upper bathyal hardgrounds, with an emphasis on Crinoidea (Echinodermata)
  PI: Charles Messing

Gulf of the Farallones National Marine Sanctuary
Investigations in the first year of the Sustainable Seas Expeditions (SSE) will focus on site characterization. The primary objectives will be to characterize subtidal habitats and assess algae, invertebrate, and fish populations. Previously, the presence of white sharks has prevented systematic investigations of the subtidal environment in this area. The DeepWorker will be used to establish transects for documenting species composition and abundance. Special attention will be given to assessing red abalone abundance and creating a species list of subtidal algae.

Scheduled Dive Projects

- Characterization of the subtidal community surrounding the Farallon Islands, California
  PI: Edward Ueber
- Creation of species list for subtidal algae at South East Farallon Island
  PI: Natalie Cosentino
- Assessment of red abalone abundance in subtidal habitats of South East Farallon Island
  PI: Edward Ueber

Ancillary Projects
These projects are subordinate to the scheduled dive projects. In many cases, the principal investigators for these projects will not be aboard. Data for ancillary projects will be collected incidentally during the scheduled dives or

as time allows. Ancillary projects may also include nighttime operations that do not involve the use of the DeepWorker.

- Ecosystem dynamics study
  PI: Dan Howard
- Deep water fish assemblage characterization for the National Marine Sanctuaries
  PI: Laddie Akins
- Survey and inventory of echinoderms
  PI: Gordon Hendler

Monterey Bay National Marine Sanctuary

Investigations in the first year of the Sustainable Seas Expeditions (SSE) will focus on monitoring fish populations at Big Creek Ecological Reserve (BCER); characterizing mid-water, day-night activity patterns at the Monterey Bay Canyon; and studying the ecology of prickly sharks. BCER off central California was designated a no-take marine protected area in 1994. To assist in resource management decisions, the effectiveness of no-take reserves must be evaluated. A baseline of benthic habitats and fauna has already been established for BCER, but long-term monitoring is critical in evaluating the reserve's effectiveness. Relative abundance, species composition, and size structure of fishes relative to depth and habitat type in BCER and adjacent unprotected areas will be quantified during SSE missions at the onset of the upwelling season in April. This will enhance the inventory of species and habitats within the sanctuary and provide data for evaluating the effectiveness of no-take areas.

Further off shore, the distribution and abundance of mid water fish and invertebrates will be assessed, comparing observations from the DeepWorker with those made from a remotely operated vehicle. The top 300 meters of the water column has only been sporadically sampled in the past. Fishes in the sonic scattering layer will be surveyed, and the results will be compared to studies from the 1950s and 1970s to assess long-term changes. The investigation on invertebrate fauna will focus on small gelatinous zooplankton. Animals such as jellyfish are often destroyed by net tows and can be difficult to observe with some remotely operated vehicles, so direct comparisons of different sampling techniques are critical.

The ecology of prickly sharks (*Echinorhinus cookei*) will also be investigated. Prickly sharks are found in tropical and temperate regions on the continental shelf or slope generally from 70 to 400 meters. Monterey Canyon is the only place that prickly sharks have been observed and tagged in large numbers. It is not known whether prickly sharks reside in the canyon or stop there along a migratory route. Additionally, very little is known about the sharks'

behavior and habitat preferences. The DeepWorker will be used to conduct visual transects at the heads of several major canyons to estimate the distribution and relative abundance of prickly sharks as well as other large sharks. The data obtained, combined with acoustic telemetry data from another study, will be used to determine habitat utilization, behavior, long- and short-term movements, and population dynamics of these sharks.

Scheduled Dive Projects

- Prickly shark ecology
  PIs: Gregory Cailliet and Richard Starr
- Seasonal comparisons of deep water habitats and fishes in Big Creek Ecological Reserve
  PI: Mary Yoklavich
- Diurnal migrations of mesopelagic organisms associated with the edge of submarine canyons
  PIs: George Matsumoto and Bruce Robison

Ancillary projects:
These projects are subordinate to the scheduled dive projects. In many cases, the principal investigators for these projects will not be aboard. Data for ancillary projects will be collected incidentally during the scheduled dives or as time allows. Ancillary projects may also include nighttime operations that do not involve the use of the DeepWorker.

- Deep water fish assemblage characterization for the National Marine Sanctuaries
  PI: Laddie Akins
- Survey and inventory of echinoderms
  PI: Gordon Hendler
- Suspension-feeding assemblages on deep shelf and upper bathyal hardgrounds, with an emphasis on Crinoidea (Echinodermata)
  PI: Charles Messing
- Assessing the fate of sediments from dredging operations in the Moss Landing Harbor
  PI: Chris Harrold

Olympic Coast National Marine Sanctuary
Investigations in the first year of the Sustainable Seas Expeditions (SSE) will focus on locating and exploring rare habitats and species in the deep sea and assessing the impacts of varying degrees of commercial fishing. Little is known about fisheries issues in the deep sea environment, yet commercial fishing is one of the most significant activities taking place in Olympic Coast National Marine Sanctuary. The Washington Department of Fish and Wildlife (WDFW) and the National Marine Fisheries Service (NMFS) have

already begun work to map trawlable and untrawlable habitats and estimate fish densities in them. Studies conducted during SSE will expand on this work. Initially, fish attraction and avoidance experiments will be conducted for testing the validity of undersea video fish counts. Fish and invertebrate populations will also be surveyed in the area that has been mapped by the WDFW and NMFS. Additionally, differences in habitat complexity and benthic macroinvertebrate species composition will be assessed in other areas of the sanctuary. Investigators hope to delineate control, lightly trawled, and heavily trawled sites within the study area for comparison. However, locating a control site, an area of no trawling, may be a challenge because mapping of trawl data indicates that very little of the outer continental shelf within the sanctuary has been left untouched.

SSE missions will assist in characterizing the physical and geological features and associated biological communities of scarcely studied areas. The sanctuary boundary encompasses the continental shelf, incised with deep sea canyons, and the upper slope of the accretionary complex formed where Juan de Fuca Plate subducts the North American Plate. Three submarine canyons (Juan de Fuca, Nitinat, and Quinault) lie within the sanctuary. Deep sea canyons are thought to serve as pathways for the flow of colder, denser, nutrient-rich water and have been shown to be areas of enhanced upwelling. They may also experience the equivalent of landslides or mudslides. The first ever cross-continental shelf video transect will be conducted by the sanctuary along with exploration missions to these mysterious deep sea habitats. Canyons will be explored, photo-documented and sampled for physical and chemical properties.

Additionally, this geological area contains active faults and erupting mud diapirs (domes formed by the squeezing out of core material) that expel exotic fluids containing hydrogen sulfide and methane. The U.S. Geological Survey (USGS) has located potential sites of fluid expulsion and/or active tectonic features, and the DeepWorker will visually locate and explore these areas. The unique physical and chemical features of these deep sea habitats likely give rise to unusual biological communities. Knowledge and understanding gained during SSE will allow resource managers to more effectively protect the resources of the sanctuary.

Scheduled Dive Projects

- Comparison of habitat complexity and benthic invertebrate communities in lightly and heavily trawled areas
  PIs: Edward Bowlby, Mary Sue Brancato
- *In situ* studies of groundfish and invertebrates in trawlable and untrawlable habitats
  PIs: Tom Jagielo, Annette Hoffmann

- Exploration of deep sea canyons within the Olympic Coast National Marine Sanctuary
  PIs: Sylvia Earle, Edward Bowlby, Mary Sue Brancato
- Cross-shelf characterization of seafloor and benthic communities
  PIs: Edward Bowlby, Mary Sue Brancato
- Fluid and gas explusion along active mud diapirs and faults, Cascadia subduction margin, Washington: A(E)ffect on benthic habitat and fisheries, and seafloor mapping
  PI: Patricia McCrory

Ancillary Projects
These projects are subordinate to the scheduled dive projects. In many cases, the principal investigators for these projects will not be aboard. Data for ancillary projects will be collected incidentally during the scheduled dives or as time allows. Ancillary projects may also include nighttime operations that do not involve the use of the DeepWorker.

- Mapping seafloor habitats
  PIs: Dwayne Peacock, Edward Bowlby
- Sampling bottom sediments
  PI: Mary Sue Brancato, Edward Bowlby
- Physical oceanography
  PI: TBD
- Surveying fish habitats and behavior
  PIs: Jack Tagart, Tom Jagielo
- Deep-water fish assemblage characterization for the National Marine Sanctuaries
  PI: Laddie Akins
- Suspension-feeding assemblages on deep shelf and upper bathyal hardgrounds, with an emphasis on Crinoidea (Echinodermata)
  PI: Charles Messing

Proposed East Coast and Gulf Missions

Florida Keys National Marine Sanctuary
Investigations in the first year of the Sustainable Seas Expeditions (SSE) will focus on assessment of the fate and effects of artificial reefs and exploration and characterization of coral reef habitat that cannot be researched by conventional diving techniques. Several artificial reefs recently have or will soon be established in the sanctuary. These artificial reefs are generally large vessels (>??meters). Use of artificial reefs in resource management is controversial. Some believe artificial reefs increase fish populations or lessen human use of natural reefs. Others believe they detract fish from their natural communities or are equivalent to dumping waste in the ocean. The

is a lack of long-term monitoring data for artificial reefs in the sanctuary to support or refute these arguments. During SSE, three recently established artificial reefs will be investigated for: disposition of the vessels' hulls; sediment toxicity surrounding the vessels; fish abundance and diversity; fish spawning aggregations; and benthic invertebrate diversity and abundance. Investigations will establish a baseline for future monitoring of long-term stability and ecological impacts of these artificial reefs.

Deep water exploration of coral reefs will be conducted to expand present knowledge of sanctuary resources and provide information important to understanding ecosystem health. It will allow scientists to compare the health of deep reefs with shallow reefs, currently monitored under the U.S. Environmental Protection Agency's Coral Reef Monitoring Project, which appear to be undergoing increases in coral disease and bleaching. Observations recently made at Conch Reef suggest reef health is better at greater depths. SSE missions will: survey the vitality of deep water coral populations; create permanently marked deep reef sites for benthic cover and species composition monitoring; determine the limits of hermatypic coral growth; and assess diseases and bleaching along transects to limits of hermatypic coral growth. Data will serve as a baseline to monitor future changes.

Coral reef exploration and characterization missions will concentrate on Carysfort Reef, Elbow Reef and the Tortugas Banks. A 1979 submersible survey described a reef system in 30-50 meters depth offshore of Carysfort and Elbow Reefs, but little is known about its present condition. The Tortugas Banks are a complex of deep reefs west and south of Loggerhead Key, Dry Tortugas. This area has important fisheries, unique coral communities, and is proposed as a portion of a Special Protection Area in the sanctuary. Because of its remote location, this area is poorly understood, yet it offers a unique setting in which effects associated with the Gulf of Mexico can be discerned from those associated with South Florida.

Proposed dive projects:

- Monitoring and vitality assessment of deep reef coral populations on the Florida Keys NMS
- Fate of artificial reefs and their long-term ecological effects
- Influence of Gulf of Mexico waters on benthic resources of the Florida Keys NMS
- Biological and geological characterization of the Tortugas Banks area

Flower Garden Banks National Marine Sanctuary

Investigations in the first year of the Sustainable Seas Expeditions (SSE) will focus on reproductive biology of mass spawning corals and characterization of deep habitats, specifically brine seeps and grabens. Coral spawning in the

Flower Garden Banks has been the subject of substantial research efforts since 1990. This research has focused on identifying participating organisms, recording their behavior, and capturing genetic material for fertilization and development studies. Researchers are now interested in determining gene flow among reef sites throughout the western Caribbean and Gulf of Mexico. Year-one SSE missions will conduct uninterrupted observations throughout the coral spawning period, conduct observation of coral spawning in habitat deeper than previously observed, and collect gamete samples.

Studies of the Banks' deep habitats are currently limited to work conducted in the 1970s. Areas of special interest include brine seeps and grabens. The Flower Garden Banks are surface expressions of underlying salt domes, pushed up as portions of 160 million year old salt layers rise through the seabed. Seawater percolating through the porous carbonate bank to the level of the salt dome produces brine seepage, most notably on the East Flower Garden Bank where water is seven times saltier than overlying seawater. The unusual chemistry of brine seeps gives rise to bizarre bacterial-based food chains. As salt layers dissolve, grabens, areas of collapsed substrate, form. The DeepWorker will be used in a comprehensive exploration of these unique habitats. Missions will likely significantly increase the species reported to date.

Proposed dive projects:

- Deep-water fish assemblages characterization for the NMSs
- Survey and inventory of echinoderms
- Faunal structure and fish biodiversity on high relief shelf/slope reef biotopes
- Reproductive biology of broadcast spawning corals at the Flower Gardens
- Exploration and study of deep water habitats of the East Flower Garden Bank
- "Eye in the Sea" (Phase 1)
- Censuses and surveys at the Flower Garden Banks NMS

Gray's Reef National Marine Sanctuary

Investigations in the first year of the Sustainable Seas Expeditions (SSE) will focus on studies of paleoenvironmental and archaeological resources and characterization of deep water fish assemblages. Previous undersea exploration at Gray's Reef has found rich and unexpected potential for significant new finds of both a paleontological and archaeological nature. SSE missions will continue research that has: discovered scientifically significant fossilized remains of nearly 12 extinct mammals from the last glacial period (the Pleistocene); obtained core and shallow excavation samples of previously unexplored buried land surfaces that have been shown to contain plant remains of a paleoecology associated with the extinct animals; and begun

construction of a paleoenvironmental/paleoclimatological model for the late Pleistocene.

Fish surveys will be conducted using standard survey methods and data forms developed by Reef Environmental Education Foundation (REEF). The REEF Fish Survey Project has been in place since 1993. It is designed to provide information necessary to assess the long-term trends of fish assemblages in popular recreation areas such as National Marine Sanctuaries. Resource managers can use this information to identify, characterize, and rectify human caused disturbances. SSE DeepWorker and scuba diving missions will collect data on the presence/absence, frequency of occurrence, and relative abundance of fish assemblages in the sanctuary.

Proposed dive projects:

- Deep-water fish assemblage characterization for the NMSs
- Paleoenvironments and archaeology at Gray's Reef

Stellwagen Bank National Marine Sanctuary
Investigations in the first year of the Sustainable Seas Expeditions will focus on deep-water fish assemblage characterization and day-night activities of fishes at deep boulder reefs. Deep boulder reefs are a common habitat within the Gulf of Maine, particularly in Stellwagen Bank. Previous and ongoing studies have shown that boulder reefs, composed of piled boulders that produce deep irregular crevices, support a unique fish assemblage. Additionally, preliminary observations suggest that species composition and activity patterns change on a diel cycle (i.e. shift from day to night-time), even at reefs as deep as 100 meters. The DeepWorker will be used to collect data on species composition, transient reef species, and behavior of fishes utilizing deep boulder reefs during day and night. This study will generate information necessary for understanding the ecology of deep reefs within the sanctuary and properly protecting resources from human disturbances.

Proposed dive projects:

- Day-night activities of fishes at deep boulder reefs

Proposed Tropics Missions

Fagatele Bay National Marine Sanctuary
Investigations in the first year of the Sustainable Seas Expeditions (SSE) will focus on the survey and inventory of echinoderms and fish assemblages. Echinoderms are a phylum of marine invertebrates with a hard internal skeleton and usually a spiny surface. Sea stars, urchins and sea cucumbers are examples of echinoderms. They play an important role in herbivory, which can subsequently affect overall ecosystem condition and health. Thus, it may be appropriate to include evaluations of echinoderms in future monitoring

programs. SSE scuba diving missions will conduct preliminary surveys of echinoderms in the sanctuary. Dives will be conducted in multiple habitats to collect, photograph and observe echinoderms. Collected specimens will be processed and housed at the Natural History Museum of Los Angeles County, a world class repository for Eastern Pacific and Caribbean echinoderms. Data will assist in establishing a baseline of the presence, behavior, distribution, and abundance of echinoderms in the sanctuary.

Fish surveys will be conducted by scuba divers using standard survey methods and data forms developed by Reef Environmental Education Foundation (REEF). The REEF Fish Survey Project is designed to provide information necessary to assess the long-term trends of fish assemblages in popular recreation areas such as National Marine Sanctuaries. Resource managers can use this information to identify, characterize, and rectify human-caused disturbances. The REEF Fish Survey Project has been in place since 1993, but not in Samoa. Surveys generally collect data on the presence/absence, frequency of occurrence, and relative abundance of fish assemblages and have primarily been conducted in the tropical western Atlantic, Gulf of Mexico, and the Pacific Coast of the U.S. SSE missions will be conducted in Fagatele Bay to inventory the fish species present and gain a better understanding of their distribution and relative abundance.

Proposed dive projects:

- Deep-water fish assemblages characterization for the NMSs
- Survey and inventory of echinoderms

Hawaiian Islands Humpback Whale National Marine Sanctuary
Investigations in the first year of the Sustainable Seas Expeditions (SSE) will focus on studies of humpback whales. Current data on humpback whale behavior is circumspect and no photographic documentation exists. Little is known about the whales' day and night activities, interaction with habitat and each other, interaction with humans and vessels, feeding and mating behaviors, and behavior during deep dives. Additionally, their behavior has never been documented at night, and it is not known how or if they sleep. The primary goal of the SSE missions will be to observe whales during such activities and at night. Data for general species and habitat characterization will be collected incidentally during missions.

Proposed dive project:

- Exploration of humpback whales

Proposed Great Lakes Missions

Proposed Thunder Bay National Marine Sanctuary

Investigations in the first year of the Sustainable Seas Expeditions will focus on locating and documenting shipwrecks in the proposed sanctuary (designation expected in late 1999). Of the projected 160 shipwrecks in the proposed sanctuary boundary, only 34 have been located. To learn more about the maritime heritage of the Thunder Bay region and to effectively manage and monitor the sanctuary's cultural resources, documentation of the wrecks is essential. Year-one investigations will entail using remote sensing (e.g., side-scan sonar, magnetometer, sub-bottom profiler) to locate shipwrecks. In subsequent years, the sanctuary could use archeological methods and the DeepWorker to document features and artifacts on located shipwrecks.

Proposed dive projects:

- Locating and documenting shipwrecks in the Thunder Bay NMS